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JPRS L/9895

5 August 1981

# Worldwide Report

TELECOMMUNICATIONS POLICY,  
RESEARCH AND DEVELOPMENT

(FOUO 10/81)



FOREIGN BROADCAST INFORMATION SERVICE

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WORLDWIDE REPORT  
TELECOMMUNICATIONS POLICY, RESEARCH AND DEVELOPMENT  
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CONTENTS

ASIA

JAPAN

- 'CAPTAIN' Computer Access System Test Results Published  
(ASAHI EVENING NEWS, 21 Apr 81) ..... 1

VIETNAM

- 'VNA' Reports on Printing of 'NHAN DAN' by Facsimile  
(VNA, 14 Jul 81) ..... 2

EAST EUROPE

CZECHOSLOVAKIA

- CSSR's Magion Satellite Systems Outlined  
(SLABOPROUDY OBZOR, Apr 81) ..... 4

Magion Satellite Design Concept, by Miroslav Studnicka  
Transmitting Equipment Described, by Jozef Plzak  
Reception of Signals From Magion, by Vaclav Grim

- Prognoz 8 Soft X-Ray Radiation Analyzer Described  
(Bohuslav Komarek; SLABOPROUDY OBZOR, Apr 81) ..... 27

WEST EUROPE

UNITED KINGDOM

- New Communications Satellite Being Built  
(Henry Stankope; THE TIMES, 22 Jul 81) ..... 37

- a -

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JAPAN

'CAPTAIN' COMPUTER ACCESS SYSTEM TEST RESULTS PUBLISHED

Tokyo ASAHI EVENING NEWS in English 21 Apr 81 p 3

[Text]

The first-stage test of the "CAPTAIN System," a new information medium which subscribers may use to request information from a computer over the telephone and receive the answer on their television screen, ended in March, and the Posts and Telecommunications Ministry and other authorities that conducted the test recently released a report on the system.

CAPTAIN stands for Character and Pattern Telephone Access Information Network. Linking 976 telephones in Tokyo, the first-stage test was conducted from Dec. 25, 1979, to March 15 this year.

Information contained in the computer includes about 100,000 "frames," including those for news, weather forecasts, quizzes and travel information.

Those making use of the system, or monitors, are limited to those living in areas under the jurisdiction of a telephone exchange equipped with electronic telephone switchboards and whose phone is of the pushphone type.

The telephone line and the TV receiving set at home are linked by means of an adapter. To use the system, one calls the CAPTAIN Center with the pushphone. After setting his TV set for reception on an open channel, he designates what he wants to know by pushing designated numbers on the keypad. Then, characters or patterns are sent via the telephone line and screened on

the TV receiving set.

During the first-stage test service period, the system was used an average of 0.72 time per telephone per day, or twice in three days. The average time used per phone call was 13 minutes and 41 seconds. The average number of frames used per call was 38.

As to which categories of information were used the most, information on events, including movies, hobbies, quizzes and games were overwhelmingly popular with 46.83 percent, followed by news and weather forecasts with 10.55 percent, education with 10.36 percent and sports with 9.83 percent. Fields that were used the least were health, beauty culture, childbirth and child rearing with 0.68 percent, followed by economic and legal questions with 0.60 percent.

Household heads used the system the most at 45 percent, followed by children, 30 percent and housewives, 18 percent.

Users apparently made use of the system with clear-cut objectives. Most household heads said that they used the system "to obtain knowledge," the housewives said they used it "to obtain information necessary for our activities" and the children answered "for study and amusement."

The second-stage test service is scheduled to get under way in August this year, with an increase in the number of

monitors and screens to 2,000 and 200,000 respectively, or double those used in the first-stage test.

If the results of the second-stage test are satisfactory, full-dress service will begin in fiscal 1983.

To the question "Will you subscribe to the system if full-fledged service begins?" asked during the first-stage test period, more than half of the respondents replied in the affirmative. It is particularly noteworthy that 75 percent of those who made active use of the test service answered in the affirmative.

To the query "What is an adequate fee for the service?" many replied "About ¥3,000 a month." Twenty percent of the respondents said they were willing to pay more than ¥3,000 a month.

The new information medium obviously is enjoying high popularity.

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VIETNAM

'VNA' REPORTS ON PRINTING OF 'NHAN DAN' BY FACSIMILE

OW210323 Hanoi VNA in Vietnamese to VNA Ho Chi Minh City 1350 GMT 14 Jul 81

[Text] [no dateline received] After the complete liberation of South Vietnam, an urgent task arising was that NHAN DAN, organ of the party, had to be widely and rapidly published throughout the country to disseminate the party line and policy among the people of the newly liberated areas. At that time NHAN DAN was being printed in Hanoi and then transported by plane or other means to Ho Chi Minh City and the southern provinces. The transportation often met with difficulties from weather conditions and in means of transportation. Due to this, we could not assure the up-to-date character of the paper every day.

In face of this, based on results obtained in the transmission of radiophotos during the war and particularly during the "Ho Chi Minh Campaign," and relying on existing equipment, VNA put forward a number of methods for transmitting the dummy of NHAN DAN from Hanoi to Ho Chi Minh City to be published locally for southern provinces on the same day. The transmission of the paper was based on the existing network of radio transmission and reception and Soviet facsimile reproducing equipment, according to the narrow-band shortwave transmission method. In the conditions where our country did not yet have a wide-band newspaper transmission facility, this method was the most appropriate one.

VNA's technical section experimented transmission of newspapers by this method from July to September 1975 and achieved relatively good results, confirming that it was practical enough to be applied on a regular basis. During the experimental process, engineers and technical cadres concerned made use of facsimile and Voice of Vietnam Radio's transmitting equipment and assured the quality of reception of the transmitted newspaper within our technical capabilities and under our country's weather conditions.

Early in 1976, after perfecting this method, VNA joined NHAN DAN and the Posts and Telegraphs General Department in organizing the regular transmission of NHAN DAN from Hanoi to Ho Chi Minh City. By this method, the first issue of NHAN DAN was officially printed in Ho Chi Minh City on 20 April 1976 and issued on the same day in the southern provinces, thus supporting in good time the election to the unified national assembly of the whole country on 26 April 1976.

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In 1978, VNA again joined NHAN DAN and the Posts and Telegraphs General Department in successfully transmitting the newspaper from Hanoi to Danang by this method. In addition to NHAN DAN, VNA has also helped QUAN DOI NHAN DAN in technical and equipment aspects to apply the transmission of QUAN DOI NHAN DAN to Ho Chi Minh City for printing there.

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CZECHOSLOVAKIA

## CSSR'S MAGION SATELLITE SYSTEMS OUTLINED

### Magion Satellite Design Concept

Prague SLABOPROUDY OBZOR in Czech No 4, Apr 81 pp 159-161

[Article by Eng Miroslav Studnicka, TELSA-VUST: "The Magion Experiment"]

[Text] Not long after Czechoslovakia entered the Interkosmos organization, TELSA-VUST [A. S. Popov Research Institute of Communications Engineering] began cooperation with the CSAV [Czechoslovak Academy of Sciences] in the development of instrumentation and equipment for the astronomical and geophysical study of space by means of satellites. Over the course of 15 years, they have successfully developed more than 200 types of instruments. The high point of our participation in the Interkosmos program has been the development and launching of the first Czechoslovak MAGION satellite. This article describes the purpose of the experiment and the design concept of the satellite and evaluates the findings that have been obtained.

### Introduction

On 14 November 1978, the MAGION satellite (international designation 1978-99C) separated from the Interkosmos 18 spacecraft (1978-99A); this satellite was intended to study the temporal and spatial structure of low-frequency electromagnetic fields in the earth's ionosphere and magnetosphere. The scientific aim of the experiment and the method of carrying it out were developed by the Institute of Geophysics, CSAV, in cooperation with the Institute of Geophysics, CSAV, in cooperation with the Institute of Geomagnetism, the Ionosphere and Radio Wave Propagation, USSR Academy of Sciences. The Magion satellite was developed and manufactured by TESLA-VUST and the laboratories of the Institute of Geophysics, CSAV, in Prague. To carry out the experiment with the Magion satellite it was necessary to provide transmitting and receiving equipment for the ground control stations, including the antennas, as well as monitoring instrumentation. Some 17 instruments were produced, most of them in several models. Thus it is clear that the project was rather extensive and required considerable effort. Accordingly, the placement in orbit of the Czechoslovak satellite, and its prolonged activity, may be considered a considerable success.

4  
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## Aims of the Experiment

The scientific aim of the experiment is to study the temporal and spatial structure of low-frequency electromagnetic fields around the earth. The investigation is carried out through simultaneous measurement of selected parameters on two spacecraft whose relative position is changing. One of the craft is the Interkosmos 18 satellite and the other the Magion satellite. These satellites move in a nearly polar, slightly elliptical orbit whose plane is inclined at an angle of  $82.96^\circ$  to the equator. The apogee of the orbit is 772 km and the perigee 404 km; the orbital time is 96.36 minutes. The Magion satellite separated from the Interkosmos 18 in the area of radio visibility from the Panska Ves station in Ceska Lipa, from which the experiment is controlled. The Magion satellite makes 15 orbits a day. It is given commands during each pass: on the average 6 to 10, but sometimes as many as 20. The number of commands depends on the length of time it is above the horizon. Some 64 quantities are measured; some of these are scientific information, while the others are information on the conditions of the satellite. The lifetime of a few weeks that was initially assumed for the satellite has been exceeded by several times. Thus it has become possible to obtain much valuable data. Of interest, for example, is the information acquired on the aging of the satellite's surface as a result of a gradual rise in temperature, which can be generalized for nonsealed objects. These and other findings can be called the technical objectives of the experiments; they will be used for subsequent projects.

## The Design Concept of the Magion Satellite

Equipment for space research has certain specific characteristics. Some of these are similar to those of equipment for ground-based radio communications and aircraft onboard equipment, namely small size and weight, minimum energy consumption, high mechanical and climatic durability, and, not least, high reliability. Among the specific characteristics of satellite equipment, we include the requirements for operation in a nonsealed environment and in a rarefied atmosphere that is close to a vacuum, and particularly such design requirements as location of the antennas and their release into working position and precise balancing. The totality of requirements exceed current practice in other areas of electronics. Because satellites generally are destroyed in the earth's atmosphere, it is difficult to determine confidently the causes of failure. As a result, in developing space objects, considerable time must be spent in tests and measurements whose results will affect the concept and design of the equipment. This was the case for the Magion satellite.

The satellite is a rectangular prism with sensors and antennas protruding from it (Fig. 1). When the satellite separated from the parent vehicle, the antennas were extended and brought into working position on a command from the earth. The Magion's antennas are linear, unipolar and dipolar types. They are installed at a certain inclination to the main axes of the satellite and are relatively small compared to the wavelengths on which they operate. The antennas for 137 and 149 MHz protrude from the bottom of the satellite and are inclined at  $15^\circ$  to the base plane. The antenna for the 400 MHz band is in the middle of the top of

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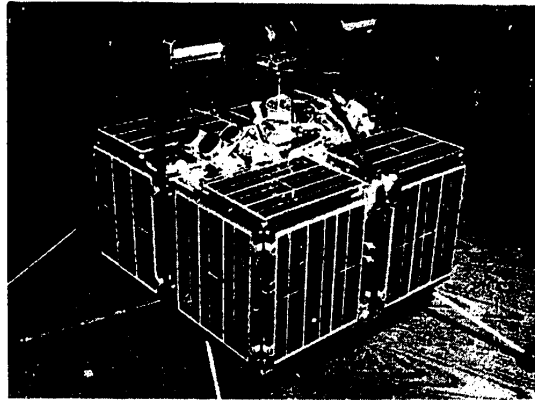


Figure 1. The Magion Satellite

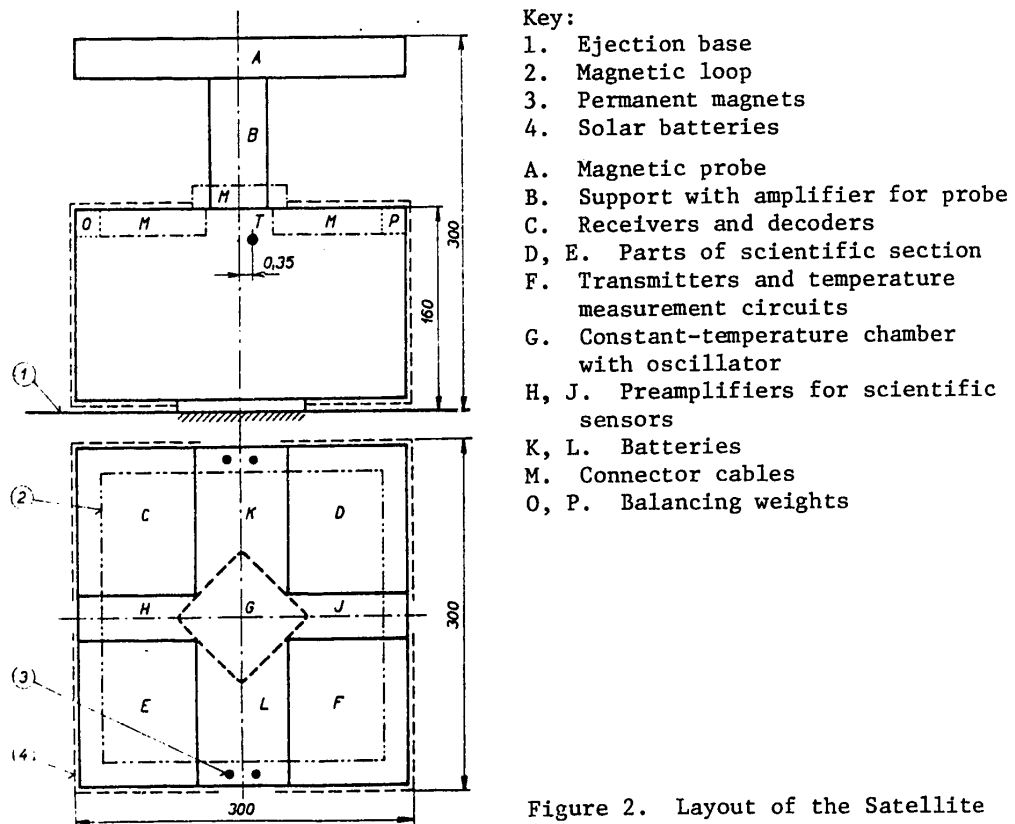


Figure 2. Layout of the Satellite

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the satellite body at the feet of the support which holds the ferrite antenna. It has a length of approximately  $0.5\lambda$  and is inclined at  $45^\circ$  to the satellite's axis. The antennas' input impedances are adjusted to 50 ohms by means of a parallel reactive component attached at a convenient place on the power supply.

Figure 2 shows the layout of the satellite. In designing the Magion it was necessary to allow for many requirements, a few of which are shown in Table 1.

Table 1. Some Requirements for the Magion Satellite

Dimensions	300 x 300 x 300 mm
Weight	15 kg maximum
Force of ejection of satellite from parent vehicle	7.845 N + 10 percent
Temperature range	+10° to +30°C
Highest permissible temperature of solar cells	+130°C
Width of ejection passage on parent vehicle	320 mm
Deviation of center of gravity from geometric axis of satellite normal to launching base	0.35 mm maximum
Linear overload along longitudinal axis of parent vehicle	10 G
Linear overload along other normal axes	1.5 G
Vibration along all axes	
5-10 Hz	0.2-1G
10-30 Hz	1-4G
30-80 Hz	4-6G
80-1500 Hz	6-10G

About half of the interior is taken up by the satellite's scientific equipment. The remainder holds the telemetric and monitoring system. The scientific equipment includes receivers for measuring the magnetic and electrical components of electromagnetic fields in a band from 0.1 to 16 kHz, a device for measuring the electric field in a band from 0.01 to 80 Hz, a unit for measuring the resonance properties of plasma surrounding the satellite at frequencies up to 8 kHz, and equipment for recording the flux of charged particles with energies above 30,000 eV in the earth's longitudinal and transverse magnetic fields.

The telemetry and monitoring system has two transmitters. One operates at 400.57 MHz with an output of 1.5 W, and the other at 137.15 MHz with an output of 150 mW. A memory unit can be used to record measurement and monitoring data when out of range of the ground-based telemetry stations. The command receivers, decoding equipment and program switching unit make it possible to control individual parts of the equipment in various modes when the satellite is passing through the radio reception region.

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The batteries are charged by solar cells which cover almost the entire surface of the satellite. The energy produced by these cells is relatively small, not exceeding 3 W. Part of the energy (about 0.7 W) is consumed by the constantly-on units, while the rest is used to charge 2 onboard batteries, each consisting of 10 NiCd cells and having a capacity of 4 ampere-hours. The scientific apparatus draws about 1.5 W; the most power is drawn by the 400-MHz-band transmitter, which accordingly only operates at certain intervals. The individual components of the onboard apparatus are on standardized boards with planar contacts and are connected by knife-type plug-in connections. Four permanent magnet bars 12 mm in diameter and a magnetic loop of permalloy tape under the solar cells stabilize the satellite in the earth's magnetic field.

The speed of ejection of the Magion from the Interkosmos 18 vehicle was chosen as 0.5 m/sec. The ejection is effected by four microswitches whose combined force of release is equivalent to the desired ejection force. The use of a lever mechanism made it possible to decrease the force of release to about one-tenth of the original value, and increased travel distance was used, providing reliable action of the ejection equipment. Because the satellite was ejected through a narrow opening in the parent vehicle, the center of gravity could not deviate more than 0.35 mm from its geometric axis. To measure the deviation of the center of gravity, a balancing device based on the principle of slow damped vibrations was produced. Precise balancing of the satellite led to positive results in mechanical tests, in which no undesirable resonances were found.

Particular attention had to be devoted to the temperature regime and energy balance of the satellite. This required many tests, for which it was necessary to design and produce various accessories, including a solar illumination simulator. In particular, it was necessary to find out what materials and surface protection should be used for the Magion. The result of the work is a framework consisting of aluminum alloy sheets of different thicknesses. The parts are connected by rivets and screws. The frame is anodized black, and the outer surfaces which are exposed to solar radiation are faced with gold-plated brass sheet whose surface was subjected to polishing between applications. A shiny layer of aluminum is vacuum-applied to the inner surface of the cap of the constant temperature chamber, forming a thermal mirror. For the most part, materials with bonded chemical substances were used as insulators. Tests and the experiment with the Magion satellite confirmed the correctness of the concept that was chosen.

## Findings Obtained

The results of the scientific tests and measurements obtained during the experiment are dealt with in separate publications. In view of the considerably greater lifetime of the satellite than was initially assumed, the amount of information obtained has also increased greatly. Accordingly, we may state that from the scientific point of view the Magion experiment exceeded the expected goals. The technical yield of the experiment may be similarly evaluated. The research and development of a satellite with sophisticated technical characteristics, made with domestically produced components, and its prolonged activity in space, have unquestionably demonstrated that correctly designed, carefully manufactured and thoroughly tested nonsealed objects can operate well and reliably in orbit and

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furnish valuable information. This experience can be used in planning and implementing new experiments with separable objects, but also in accomplishing other tasks in other areas of electronics.

Conclusion

The Magion satellite has lived up to expectations. The experiment has made it possible to obtain valuable experience and has created good conditions for more extensive projects. One of them may be the simultaneous launching of two or more such satellites. The instruments developed and fabricated for the experiment gave a good account of themselves and operated reliably. The results confirm that the electronics industry is capable of producing instruments with excellent capabilities and of using its findings effectively in the performance of other tasks. This is a specific and direct benefit of informal cooperation in the Interkosmos program.

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Transmitting Equipment Described

Prague SLABOPROUDY OBZOR in Czech No 4, Apr 81 pp 162-166

[Article by Eng Jozef Plzak, CSc, TESLA-VUST: "Transmitting Equipment for the Magion Satellite"; bibliography not reproduced]

[Text] This article describes the communications system of the Magion project and the conception and design of the command link transmitters and of the onboard 137-MHz and 400-MHz transmitters.

1. Introduction

The Magion satellite is a small satellite, but the range of its basic functions is comparable to that of large scientific satellites. Accordingly, the communications system must perform all the basic functions of large satellite communications systems. Thus, one-way telemetric and identification communication is insufficient: the control center must have the capability of controlling the satellite's operating mode by means of a command link, supported by a distance-measuring system and having the possibility of checking from the ground the transmission parameters of the command and telemetric communications.

The transmitters of the Magion project were developed by our institute. The 200-watt command transmitter operates in the 150 MHz band, the onboard 0.3-watt transmitter in the 137 MHz band and the onboard 2-watt transmitter in the 400 MHz band.

2. The Command Link

The command link is intended to transmit commands from the ground station to the satellite. It consists of the command transmitter, the transmitting antenna,

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the receiving antenna and the command receiver. The command transmitter is connected with the control console and the command receiver is connected to the unit controlling the operating mode of the satellite. The command-link is characterized by the following basic figures:

working frequency	150 MHz
modulation	narrow band FM
modulation swing	$f_{\max}$ 5 kHz
modulation frequency	100-3,500 Hz
gain of directional transmitting antenna	$G_1 = 15$ dB
maximum distance	$\ell = 3,500$ km
receiver noise figure	$n = 5kT_0$
gain of satellite receiving antenna	$G_2 = 1$ dB
losses from nonidentical antenna	$L_{\text{pol}} \approx -3$ dB
polarization	
maximum gain difference as a result of directionality of satellite antenna	$\Delta L \approx -15$ dB
losses in cables and connections	$L_x \approx 1$ dB

Reference 1 gives the following figures:

noise figure of receiving system	$n = 11.1$
noise power at receiving antenna	$N_s = -151.6$ dB <sub>w</sub>
required power at receiving antenna	$N_p = -141.6$ dB <sub>w</sub> (for a 10 dB noise interval at limiter)
attenuation in free space	$L_0 \approx 147$ dB
required transmitter power	$N_v \geq 9.6$ W

On closer inspection, it is evident that it would be very difficult to improve the parameters of the onboard part of the communications system (i.e., the receiving antenna and command receiver). Similarly, the transmitter antenna gain is an optimal compromise between directionality, dimensions and flexibility. Accordingly, the only realistic remaining potential lies in the command transmitter power. In practice, the power of command transmitters is many times higher than the required value. It is chosen as high as 15 kW, which provides a reserve for reception under extreme conditions such as powerful interference signals, decreased receiver parameters resulting from extreme temperatures, a decreased feed voltage and the like.

### 3. The Command Transmitter

The command transmitter is used to transmit coded commands from the control center to the satellite, to measure the distance to the satellite and to measure the entire communications path. The command link must make possible control of satellite operation by means of the requisite number of unambiguous commands during the entire period of radio visibility of the satellite. The reserve power for unfavorable receiving conditions and extreme situations should be sufficient to avoid production of spurious radio commands by an undesirable signal from another command, or by a chance modulation structure. Particularly great emphasis is laid on the reliability of the command link.

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Careful consideration of the limiting factors on board the satellite (dimensions, power consumption, extreme working conditions) and availability of components led to adoption of an economical coding system. The command combination consists of a serial combination of three tones chosen from four different possibilities. Immunity to random interference signals is assured by a fixed address which precedes the command combination and a system of tone detectors which are interference-resistant. The entire command combination is transmitted during an interval of less than a second. There are 24 command combinations available. This simple command system makes it possible to design simple onboard evaluating circuits with satisfactory properties. More detailed information on the coding and evaluation of commands is given in reference 1.

In addition to discrete commands, 400 and 500 Hz signals can be emitted for distance measurement. Finally, both transmission links (command and telemetric) can be checked by means of a modulating signal from an external source or a 1-kHz internal signal. The distance to the satellite can be measured by phase comparison of the emitted and returning 400 and 500 Hz signals, which are switched at intervals of 1/20 second. The entire communications path can be checked by a permanently-on 1 kHz modulating signal which is sent back by the telemetry transmitter, or by any other external modulation.

The command transmitter consists of two units. The control section is a component of the control station, which is located about 100 meters away from the antenna system. The output section of the transmitter is built into the antenna system and forms a unit with the transmitting antenna. Because of the extraordinary requirement for command-link reliability, the output stage consists of four parallel output modules.

Figure 1 is a block diagram of the control section. In addition to the signal-emitting circuit, the modulation circuit and the control components, it contains radio-frequency exciter circuits. Figure 2 is a photograph of the unit.

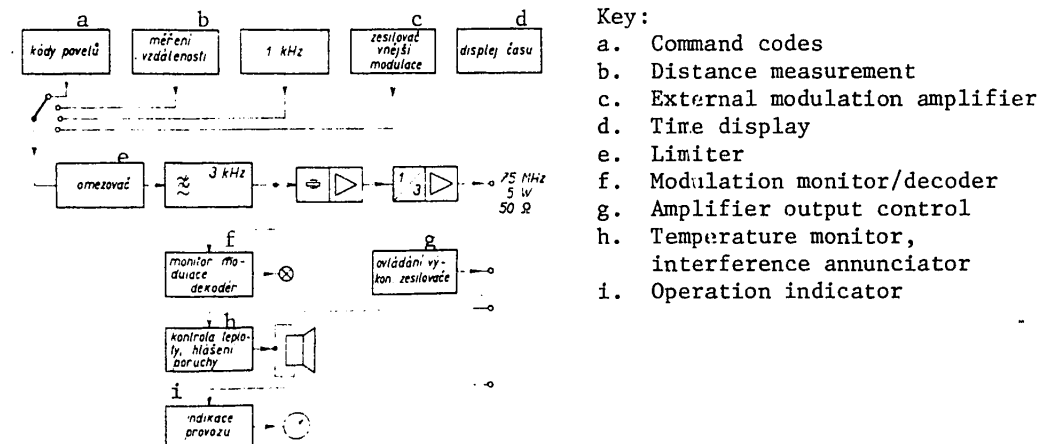


Figure 1. Control Section of the Command Transmitter

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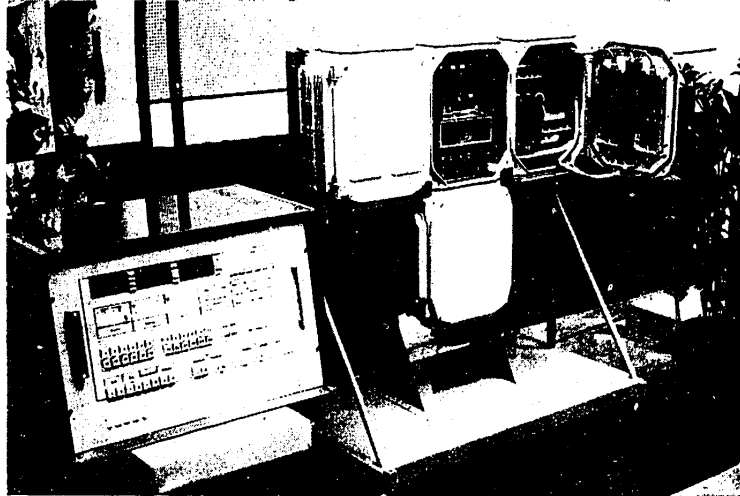


Figure 2. The Command Transmitter. Control section on left, output section at right.

The RF exciter signal is fed from the frequency-modulated crystal oscillator through the multiplier to the amplifier stage. The RF exciter feeds a power of 10 W at half the working frequency into the cable which connects the control section with the output section. The exciter output is protected from short circuits and disconnection. The exciter uses conventional semiconductor circuitry. Its specifications are given in Table 1. The control panel, assembled from the Mozaika kit, includes all of the transmitter's control and monitoring components, command buttons and a digital clock. It indicates the current output power of the exciter and the output and reflected power of the power amplifier. The temperature of the output-section cooling devices and of the transformer windings in the power supplies is monitored. If an excessive temperature occurs in any location, an audible signal is given. The correctness of the emitted signal is evaluated by comparing the detected and decoded RF signal with the resulting code combination and is indicated visually.

The output section is installed in a nonairconditioned vehicle to whose roof the transmitting antenna is attached. Thus it is exposed to temperatures from  $-25^{\circ}$  to  $+55^{\circ}\text{C}$ . In formulating the requirements it was assumed that a reserve power of 13 dB would suffice in all extreme cases, and accordingly it was determined that the output power of the command transmitter would be 200 W. The KT 922 V output transistors which were available can put out only 40 W, or 70 W in a balanced connection. The extreme requirements for command-link reliability could be met only by redundancy of the circuits with the lowest reliability. Many years' experience with RF power amplifiers indicates that it is they, and particularly their power transistors, which are the most critical part of the transmitter. Accordingly we sought a design which would make it possible to combine the outputs of the main amplifiers in such a way as to achieve the

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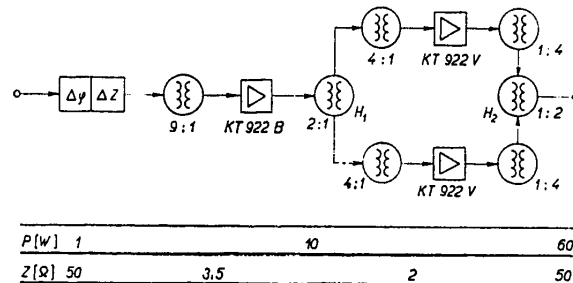


Figure 3. Wiring of Main Power Module

operation is different (the power divider must be scaled to a considerably higher power). It is worth noting that the power coupler increases resistance to breaks and shorts (it decreases  $CSV_{\infty}$  to  $CSV_5$ ).

To the output of the parallelizer is connected a 7-component Chebyshev low-pass filter, followed by a stripline reflectometer. The reflectometer outputs are used for indication and the reflected power output for protection against mismatching. The divider is connected to the multiplier and amplifier cascade, which uses conventional circuitry, whose power amplification is controlled by the reflectometer (protection against mismatch). Details of this amplifier design are given in reference 2. Figure 4 shows a block diagram and Figure 5 a photograph of the unit. The importance of this mastering of wideband microwave power amplifier technology and of power coupling on the order of hundreds of watts goes beyond the confines of the Magion project. Altered versions are usable for a number of other applications in the frequency range from 150 to 185 MHz in both mobile networks, public radiotelephone networks and other ground-based radio communications. But in essence the route to transistorization of medium-power transmitters has been opened, and the result in prolonged, demanding operation has been positive.

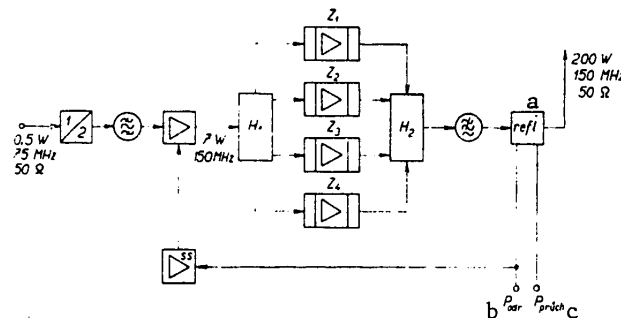


Figure 4. Power Section of Command Transmitter

Key:  $H_1$ . Hybrid divider  
 $H_2$ . Hybrid coupler  
 $Z_1-Z_4$ . Main power modules  
a. Reflectometer  
b. Reflected power  
c. Transmitted power

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Table 1. Transmitter Specifications

Specification	Ground-based transmitter		Onboard transmitter	
	Exciter	Power amplifier	137 MHz	400 Mhz
Working frequency (MHz)	74-75	148-150	137.150	400.01
Frequency stability	$2 \times 10^{-5}$	$2 \times 10^{-5}$	$2 \times 10^{-5}$	$5 \times 10^{-8}$
Short-term frequency stability (1 second)	not spec.	not spec.	not spec.	$3 \times 10^{-11}$
Type of modulation	FM	FM	FM	M
Modulation shift	2.5 kHz	5 kHz	10 kHz	80°
Maximum modulating frequency (kHz)	3.4	3.4	50 kHz	40 kHz
Modulation distortion (percent)	2	2	1	2
Suppression of spurious emissions (dB)	60	60	50	60
Temperature stability(°C)	+5 to +45	-25 to +55	-50 to +60	-20 to +50

the required power and to assure that the breakdown of one or more amplifiers would not affect the operation of the others, and finally so that the amplifier would be operational for a long period even if certain of the power transistors broke down. A solution was found in conphasal paralleling, achieved by means of line ("impedance") transformers.

This paralleling arrangement can be made in a rather wide-band design which utilizes the superior isolating properties of the individual amplifier branches. But their output powers can be paralleled only in the case of good conphasality ( $\Delta\varphi \leq 5^\circ$ ) and long-term phase stability. But these preconditions can be achieved only with broadband amplifiers. The ultimate design of the basic amplifier module is shown in Figure 3. The amplifier module contains two bypass sections utilizing line ("impedance") transformers, whose properties and manufacture are described, for example, in reference 3. The amplifier is a two-stage design: the first transistor (exciter) is matched to an input impedance of 50 ohms and feeds a hybrid divider which is connected to the two-element final stage. The impedance of the divider is matched to the base of the final-stage transistors by 4:1 line transformers, while 1:4 line transformers match the collectors to the hybrid coupler, whose output impedance is again 50 ohms. The amplifier is absolutely stable in the entire range of working temperatures and the phase stability is excellent. At the amplifier output is a circuit which allows the amplifier phase to be adjusted to the desired value.

These four modules are paralleled by means of a conphasal power coupler at the output and a conphasal power divider at the input. The divider and coupler are similarly connected, and their functions are reciprocal, but their actual

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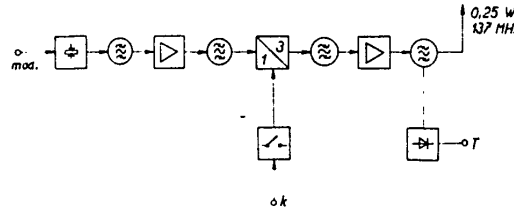


Figure 5. Group Wiring of 137 MHz Transmitter

## 4. The Onboard Transmitters

The transmitters on board the satellite are used to identify the satellite and to transmit telemetric data of a service character (information on the condition, operating regime and operating conditions of the satellite's onboard equipment) and scientific data and make it possible to measure certain parameters of the satellite's orbit. The frequencies in the 137 and 400 MHz bands are reserved for this type of communications. The 137 MHz band is a standard band and all the countries cooperating in the Interkosmos program are equipped for reception in it. The 137 MHz band is, however, relatively crowded, there is interference with other services, and it is designated for only narrow-band transmissions. Nor is it suitable for determining precise orbital parameters, for the ionosphere still affects the phase of the reflected signal. The 400 MHz band can be used both for precise orbit determinations and for broadband transmission, however, requires a higher transmitter power.

In the initial communications design it was necessary to allow also for power levels on the satellite: the average energy drawn from the solar batteries was not to exceed 3 W, including 0.7 W consumed by constantly-on instrumentation. Accordingly it was decided to use the specific properties of both frequency bands and to carry out communications by means of a pair of transmitters.

## 5. The 137 MHz Transmitter

The transmitter in this band was given the role of the basic, constantly operating transmitter, functioning in the "beacon" mode from the moment of separation. In this mode it transmits a keyed carrier with a repetition frequency proportional to the voltage in the onboard electrical system and with a rest-to-signal ratio proportional to the temperature of the satellite. Operation in the "beacon" mode makes it possible to identify the satellite, track its orbit and perform basic monitoring of the condition of the onboard batteries and the temperature of the satellite.

The satellite changes to the telemetry-data-transmission mode only on command from the control station. This involves so-called "slow telemetry," in which a series of service data (up to 200 monitored satellite parameters) and certain slowly-changing output values of the scientific apparatus can be transmitted in time-division form via the subcarrier. In telemetric monitoring it is possible to duplicate the transmission of certain data intended to be transmitted on the other transmitter. Thus the 137 MHz transmitter is the basic piece of satellite

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instrumentation. If it were to carry out all of the required functions in a wide temperature range (for which only estimated absolute values were available) and in a wide voltage interval with high reliability and low power consumption, it would be necessary to choose a simple, well-tested and nonproblematical design. There was no experience at all with nonsealed, nonclimate-controlled satellites. Accordingly, allowance was made for operating temperatures from  $-40^{\circ}$  to  $+60^{\circ}\text{C}$  in a temperature regime which guaranteed all parameters between  $-30^{\circ}$  and  $+50^{\circ}\text{C}$ , assuming battery voltage variation between 8 and 13.5 V.

The transmitter conception is evident from Figure 6. The parameters are given in Table 1. In particular, it is necessary to raise the frequency stability, considering that it involves a modulated oscillator and an extreme operating regime. The oscillator circuitry is given in reference 4. The transmitter not only achieved the required parameters, but also attained operability in a wider range than was required, as shown in Figures 7 and 8.

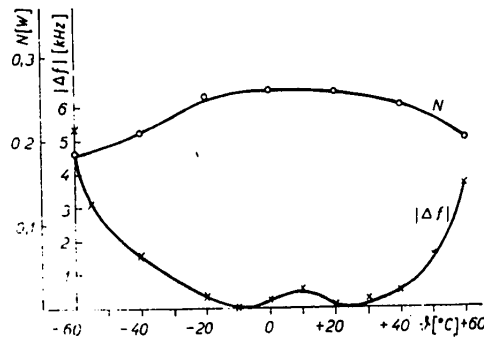


Figure 6. Output Power and Frequency Stability of 137 MHz Transmitter as a Function of Temperature

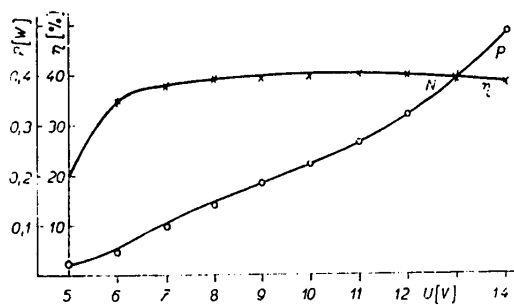


Figure 7. Output Power and Efficiency of 137 MHz Transmitter as a Function of Onboard Power Supply Voltage

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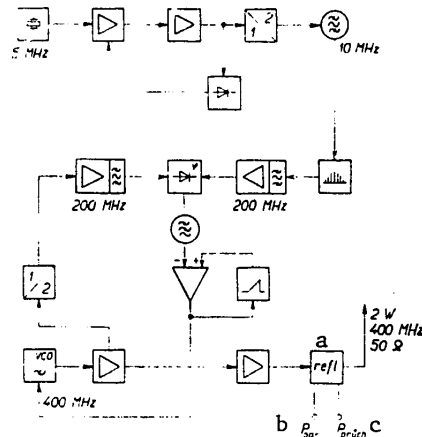


Figure 8. Wiring of 400 MHz Transmitter

Key: a. Reflectometer      b. Reflected power      c. Transmitted power

## 6. The 400 MHz Transmitter

This transmitter is designed for broadband transmission of scientific information of a continuous character (e.g., the spectra of ionospheric whistling) and for determining the distance between the satellite and the control center. The transmitter operates for brief periods. Stringent requirements were imposed regarding frequency stability, efficiency and frequency purity. These requirements affected the choice of circuit design. The most stable Czechoslovak type, the PKJ (SDY/53-22) emits at a frequency of 5 MHz. The conversion from this frequency to 400 MHz makes it possible to achieve phase synchronization by multiplication, synthesis or some other technique. For 80-fold multiplication, a  $5 \times 4 \times 2 \times 2$  cascade of multipliers is most suitable. Filtering out of undesirable frequencies requires selective bandpass filters, which however have a low transfer efficiency, so that the multiplier cascade must operate at a rather high power level, as a result of which the high efficiency condition can be difficult to achieve. Frequency synthesis is complex to implement with available components and consumes large amounts of power. Accordingly, the simplest phase-synchronization system was sought. The reference oscillator output is doubled and fed to a superreactive multiplier with a selective amplifier. The transmitter signal is sampled, divided and compared with a processed sample of the reference voltage in a phase detector, whose output is filtered and amplified by an operational amplifier. The operational amplifier in turn controls the variable capacitor of the 400 MHz power oscillator. This oscillator is made with a high frequency cascade followed by two power stages.

The development of both oscillators was extremely challenging. The reference oscillator operates in an ultrastable connection with an automatic output voltage regulator. It is located in an electronic constant temperature chamber whose temperature is maintained within  $\pm 0.2^\circ\text{C}$ . A power oscillator stability of

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$2.5 \times 10^{-4}$  over the entire range of temperatures and onboard variations was at the outer limits of design capabilities.

A frequency of 200 MHz was chosen for phase comparison. This frequency was chosen as the optimal compromise between linearity of phase modulation and background level. The parameter settings of the low-pass filter and DC amplifier connected to the phase detector are rather critical if the circuit is to assure reliable synchronization and the required frequency dependence of the modulation characteristic. To the positive side of the operational amplifier is connected a circuit which wobbles the control voltage of the controlled oscillator in case the phase relationship is not synchronized.

The transmitter was fabricated using stripline techniques. It is described in more detail in reference 4.

The measured parameters are shown in Table 1. In operating the transmitter it was found that the weakest point in the system was the phase-suspension circuits. On the basis of power considerations, the selective amplifiers feeding the phase detector were not saturated, so that a certain change in their output voltage led to a change in the operating conditions of the phase detector, and thus to a change in the modulation and synchronization properties. With this exception the conception chosen has proven to be correct.

#### 7. Conclusion

This article has described the communication system of the Magion project and the conception of the transmitters used. The experience acquired in this work goes beyond the Magion project and is entirely usable in the accomplishment of other tasks of the national economy.

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#### Reception of Signals From Magion

Prague SLABOPROUDY OBZOR in Czech No 4, Apr 81 pp 167-170

[Article by Eng Vaclav Grim, TELSÁ-VUŠT: "Reception of Signals From the Magion Satellite"]

[Text] This article describes the equipment of the center for controlling the operation and receiving the signals of the first Czechoslovak Magion satellite at the observatory of the Institute of Geophysics, CSAV in Panska Ves, and the equipment which was manufactured for the purpose by TELSÁ-VUŠT.

Together with the set of onboard equipment for further study of the earth's magnetosphere, the AUOS-Z-MAG-IK automatic universal orbital station (IK [Interkosmos] 18 satellite), which was oriented in the direction of the earth's gravitational field vector and the velocity vector, also carried the first Czechoslovak Magion satellite. After stabilization, a check of orbital parameters

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and testing of the basic system functions, the latter separated from the former on 14 November 1978, thus becoming an independent satellite which began to perform tasks assigned it by the control and receiving station in Panska Ves.

The Magion satellite carried receivers for measuring the magnetic and electric components of the electromagnetic fields in a frequency range from 100 Hz to 16 kHz, devices for measuring the electric field in a range of frequencies from 0.01 Hz to 80 Hz, a unit for measuring the resonance properties of the medium surrounding the satellite at frequencies up to 8 kHz, and equipment for recording the flux of charged particles (electrons) with energies above 30 keV in directions along and transverse to the earth's magnetic field, to which the satellite was oriented. The IK 18 satellite had analogous instruments and other equipment for measuring and recording the electric field of the earth and its changes, instruments for analyzing the surrounding medium, and equipment for determining the direction of movement and intensity of the changed particle flux, as well as other instrumentation. A common purpose of both satellites was that of determining the temporal and spatial changes of the phenomena that were monitored.

Simultaneous reception of the signal from both satellites, moving in approximately identical orbits and gradually moving apart, required that the receiving station be equipped with two mutually independent program-controlled antenna systems. Because it is convenient to separate the local transmission of commands for the Magion satellite from the reception of its telemetric signals, another transmitter antenna for the 149 MHz band was also earmarked for this satellite. Transmissions from the Interkosmos 18 satellite are made at frequencies of 136.35 MHz and 137.85 MHz using two TC-2-C transmitters, on which more detailed information can be found in references 1 and 2. Signals from the Magion are received at frequencies of 137.15 and 400.57 MHz. The information is transmitted in various operating modes, in direct telemetry and from recordings (on onboard tape recorders on the IK 18 satellite and in memory registers on the Magion). The noise spectra and low-frequency phenomena in the magnetosphere are transmitted in analog form. These levels and the data on operating parameters are transmitted as modulation of subcarrier frequencies. On the IK 18, slow measurements are for the most part made in digital form and transmitted either directly or from recordings on digital tape recorders.

The signals from both satellites are received by TS-2-P two-channel receivers, always two receivers for each satellite. This redundancy not only assures reliability but in particular allows monitoring of operating conditions during each contact with the satellite while it is passing over the ground station without interrupting the recording process. With an apogee up to 1,000 km, the orbital time is about 90 minutes. Accordingly, every day two or three passes can be recorded in the upward orbit (from south to north) and two, or at most three, in the downward orbit. The orbital parameters are determined and tracked in advance, and used to calculate the program for aiming the TC-1-A and TC-2-A directional antennas, which are equipped with low-noise TC-1-Y, TC-2-Y and AZ 400 antenna amplifiers. Depending on the height of the orbital apogee and its apogee and its position relative to the receiving station, the connection lasts from 6 to 15 minutes. In this time, the necessary commands both for

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switching from the beacon mode (A1) to telemetric transmission and for turning on the working mode of the satellite for the required measurements must be transmitted. After monitoring the charge on the onboard battery, which depends on the ratio of the amounts of time the satellite spends in the illuminated and dark parts of the orbit, the scope of the measurements must be changed; when these are completed, back into beacon-mode operation, i.e., to a keyed carrier signal on the 137 MHz band transmitter. The keying frequency is determined by the voltage of the onboard battery and the ratio of rest to signal gives the current temperature inside the satellite. The time of illumination of the satellite and the time spent in the dark vary in accordance with the orientation of the practically constant orbital plane of the satellite in space as the earth moves around the sun. The supply of energy in the onboard chemical batteries, which are charged by solar cells, thus determines the overall scope of measurements and the time after which the required telemetric information can be transmitted.

To monitor the operating readiness of the ground station for recording of information, before the connection and between connections, simulators of the signals from the satellite transmitters are briefly turned on so that no time will be lost in case of operator error or failure of one of the instruments between the antenna and the recording equipment.

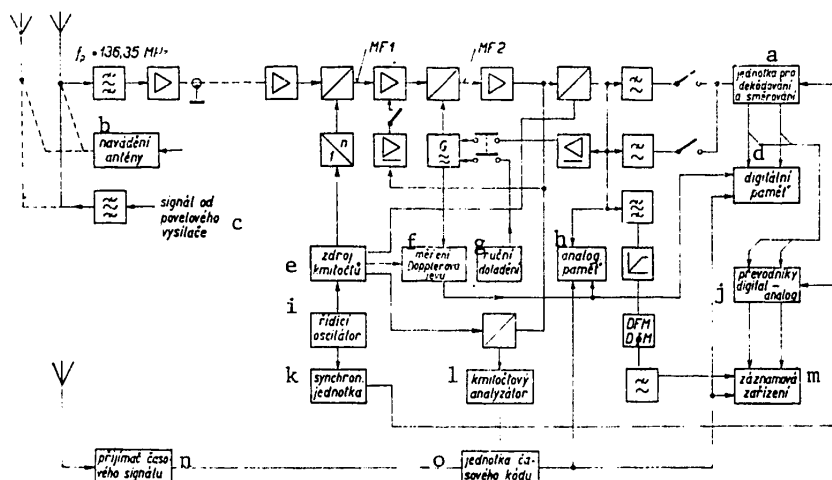
Analog signals with frequencies up to 16 kHz from the output of the TS-2-P receiver are recorded on TESLA B43 tape recorders along with time data from the secondary ACES time-standard unit (Institute of Radio Engineering and Electronics [URE], CSAV). At the same time, they are fed to the subcarrier frequency demodulators (Synchron) and from these to multichannel recorders (Chirana), where they are recorded.

In transmissions from the IK 18 satellite, in which analog information in a spectrum up to 60 kHz is transmitted from onboard TC-2-M tape recorders (VZLU [Aeronautical Research and Testing Institute]), the signals are recorded on a Bell and Howell tape recorder, from which they are played back at quarter speed, i.e., in a spectrum corresponding to the recording on board the satellite, i.e., in a spectrum corresponding to the recording on board the satellite, and fed to a TESLA B43 tape recorder, to the subcarrier frequency demodulators and from them to the Chirana recorder. The digital signals from the first signal shapers in the TS-2-P receivers are fed to the regenerator and synchronizer and then to the channel divider (UE [Institute of Electronics], GDR Academy of Sciences, and URE CSAV). From there, three selected channels (of 64 broadcast simultaneously) can be fed to the recording equipment. The entire digital signal is recorded on a tape recorder. It can be played back from this tape recorder for processing of other channels on the synchronizer and then recorded in computer memory.

To record and process signals transmitted in digital form, the station is provided with a PRS 4000 computer (Robotron, East Germany), with a control unit and a high-speed printer. A SPOZA device (ZPA [Machinery and Automation Plants]) is used for converting analog information into digital form.

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To monitor the orbital parameters of both satellites and to determine their distance, an MDP 4K Doppler frequency-shift measuring device was developed and phase measurement was arranged at two frequencies (400 and 500 Hz) between the signals' arrival at the modulator of the ground-based command transmitter and their arrival at the ground-based receiver, i.e., after their transmission from the earth to the satellite and back. To limit interference, which results in undesirable dispersion of the measurement values in certain time periods and to increase precision, variable quantities must be recorded in the shortest possible time (in this case, about 0.1 second) and with the shortest possible intervals ( $\leq 1$  second). For direct frequency measurement in the 400 MHz band, it will be necessary to use counters for frequencies up to 4 GHz with a short-term stability better than



Key:

a. Unit for decoding and routing	i. Control oscillator
b. Antenna guidance	j. Digital-analog converters
c. Signal from command transmitter	k. Synchronizer
d. Digital memory	l. Frequency analyzer
e. Frequency generator	m. Recording equipment
f. Doppler measurement	n. Time-signal receiver
g. Manual tuning	o. Time-code unit
h. Analog memory	

To monitor the orbital parameters of both satellites and to determine their distance, an MDP 4K Doppler frequency-shift measuring device was developed and phase measurement was arranged at two frequencies (400 and 500 Hz) between the signals' arrival at the modulator of the ground-based command transmitter and their arrival at the ground-based receiver, i.e., after their transmission from the earth to the satellite and back. To limit interference, which results in undesirable dispersion of the measurement values in certain time periods and to increase precision, variable quantities must be recorded in the shortest possible time (in this case, about 0.1 second) and with the shortest possible intervals ( $\leq 1$  second). For direct frequency measurement in the 400 MHz band, it will be necessary to use counters for frequencies up to 4 GHz with a short-term stability better than

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$1 \times 10^{-9}$ , but no such equipment is available. Accordingly we employed mixing with extremely stable oscillators in a band suitable for counting and recording on available counters. The Doppler frequency-shift for satellites orbiting the earth at about 8 km/sec with a transmitter frequency in the 137 MHz band is roughly  $\pm 3.5$  kHz, while it is  $\pm 10.5$  kHz in the 400 MHz band. The highest rate of frequency change while the satellite is passing directly over the receiving station is 70 Hz for low orbits in the former band and 200 in the latter band. At the limits of the overflight period and of radio reception, the frequency changes will be on the order of several Hz. If it is expected to be necessary to measure the frequency after reception in time intervals less than 1 second, the requirements for short-term frequency stability of the oscillators in the transmitters and receivers and in the measuring equipment itself are between  $1 \times 10^{-9}$  and  $3 \times 10^{-9}$ . The stability of the satellites' oscillators cannot be improved. It is determined primarily by the stability of the transmitter operating regime. The receiver oscillators are tuned to the transmitter frequencies with a deviation of less than 1 Hz. The measurement results can be improved primarily through the frequency stability of the mixing oscillators. When these oscillators have a higher long-term stability it is possible to gradually eliminate errors resulting from frequency instability of the onboard transmitters as well as those resulting from the measurement process.

A block diagram of the doppler measuring device using TS-2-P receivers is given in Figure 2. The location of the special receivers ordinarily used for these measurements is occupied in this case by the receivers for the satellite signals.

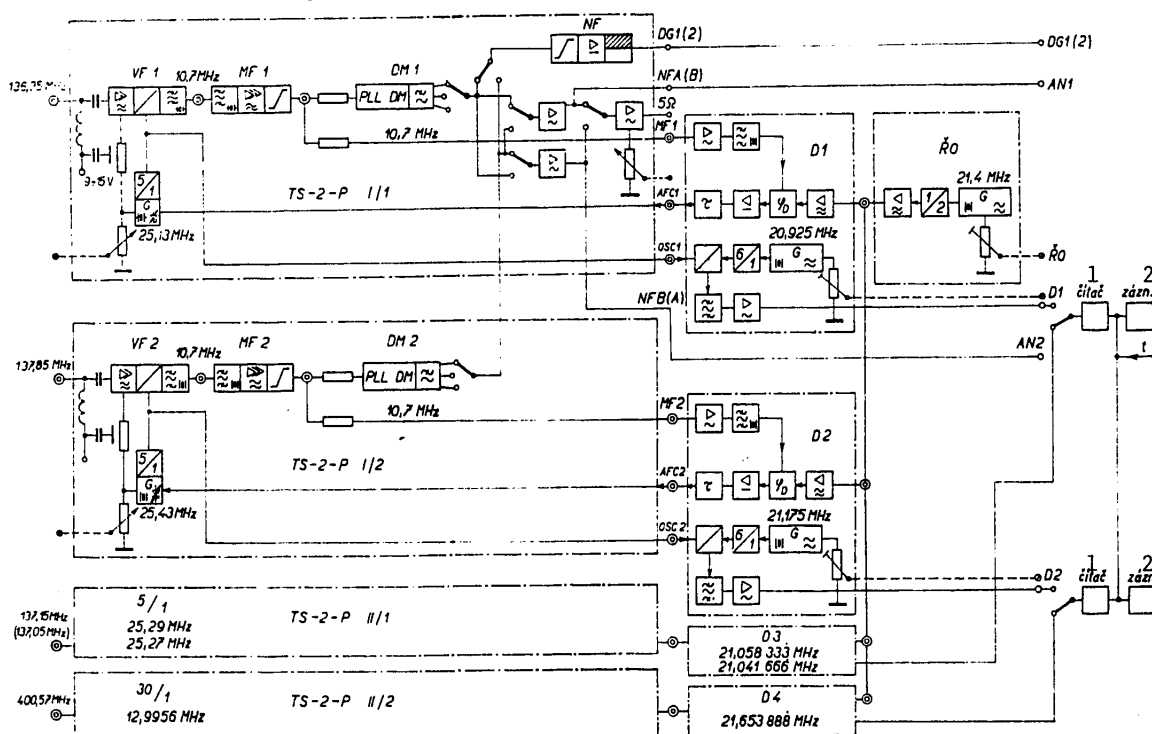


Figure 2. Block Diagram of Doppler-Phenomena Measuring Device Using TS-2-P Receiver

Key: 1. Counter  
2. Recorder

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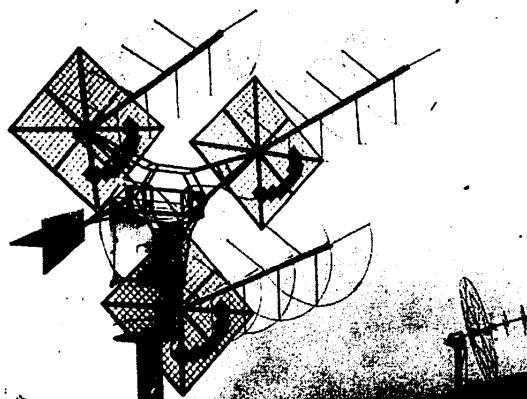


Figure 3. Directional Antenna for 149 MHz Command Transmitter ( $G \approx 16$  dB)

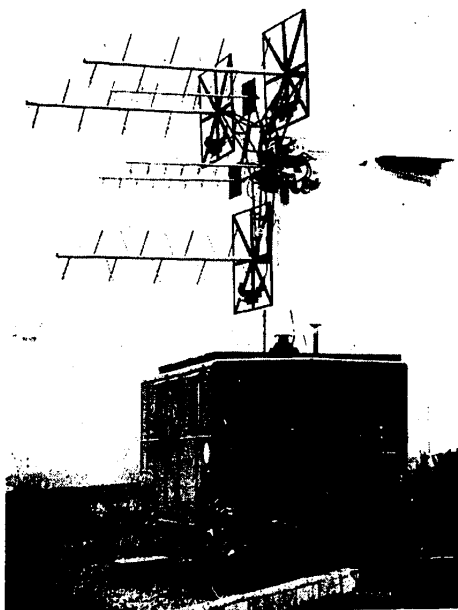


Figure 4. TG-2-A Two-band Directional Antenna System for receiving signals from the Magion satellite (137 and 400 MHz bands,  $G = 17$  dB). The system includes the TC-1-Y ( $F \approx 2kT_0$ ,  $G \approx 20$  dB, allowable distance between antenna and receiver 100 m) and AZ 400 ( $F \approx 4.5kT_0$ ,  $G \approx 20$  dB,  $l_{k,max} = 100$  m) antenna amplifiers.

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The basic data on the TESLA-VUST instruments are given in the photo captions. The equipment is described in more detail in relevant references.

The equipment at the center for controlling the flight and receiving the signals of the first Czechoslovak Magion satellite concluded an important stage in the preparation of equipment for scientific space research and in the preparation to use it for the further development of the Czechoslovak economy in the future.

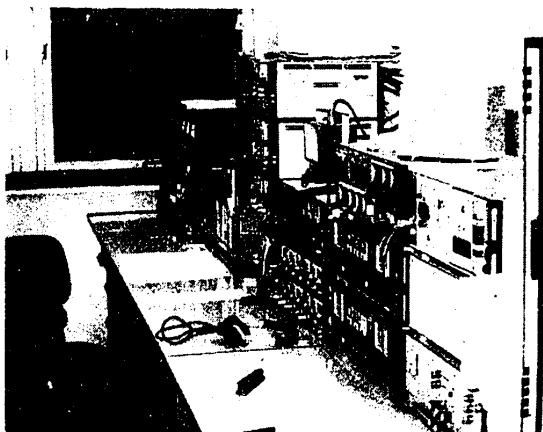


Figure 5. Operator's Station for Control of Operations and Reception of Signals From the Magion Satellite.

From left: control panel of the command transmitter, equipment for programmed antenna guidance, two pairs of TS-2-P receivers for signals from Interkosmos 18 and Magion, device for decoding service and telemetric information from the sub-carrier frequencies of the transmitters, device for manual guidance of the antennas to their initial positions, equipment for demodulating digital signals from the IK 18 satellite, secondary ACES time standard, and tape recorders for broadband recording of analog signals and digital signal.

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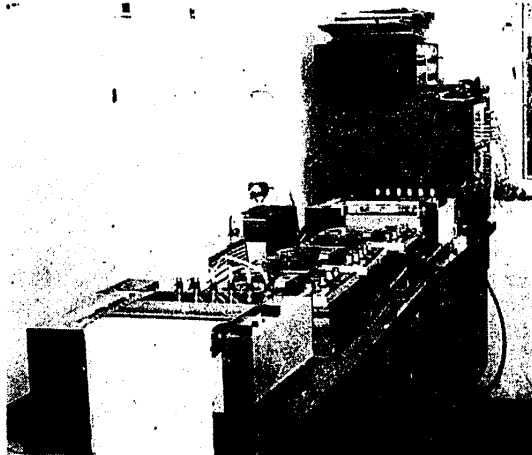


Figure 6. Station for Recording Analog Signals from Magion and IK 18 Satellites, With Chirana Recording Unit and TESLA B43 Tape Recorder.

At right is SPOZA unit, used for converting analog signals to digital form, and monitor receiver (Institute of Electronics, GDR Academy of Sciences).

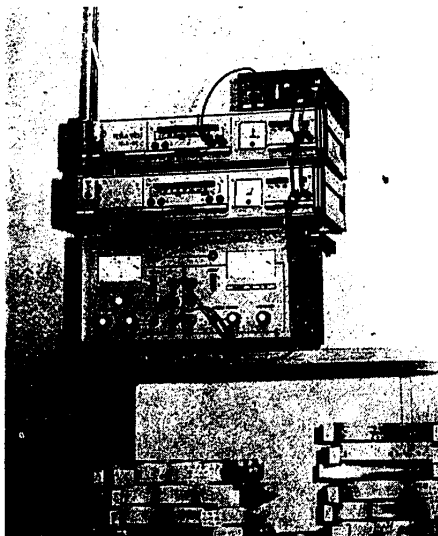


Figure 7. Simulator of Signals From Onboard Transmitters (TC-2-CK) With Digital Data Source and Power Supply

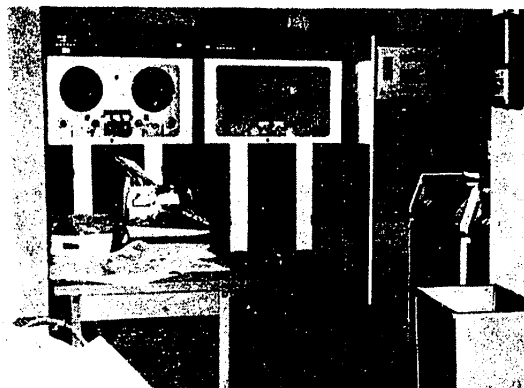


Figure 8. Memory Units of PRS 4000 Computer, for Recording Digital Signals

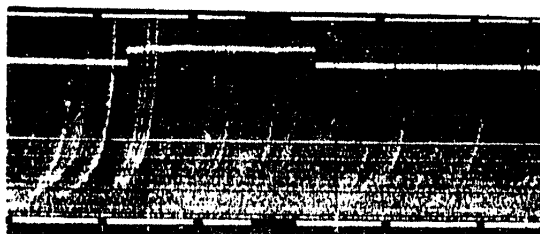


Figure 9. Recording of Low-Frequency Phenomena in the Earth's Magnetosphere  
Processed by AS 1 Analyzer

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PROGNOZ 8 SOFT X-RAY RADIATION ANALYZER DESCRIBED

Prague SLABOPROUDY OBZOR in Czech No 4, Apr 81 pp 172-175

[Article by Eng Bohuslav Komarek, TESLA-VUST: "An Analyzer of Solar Soft X-Rays for the Prognoz 8 Satellite"]

[Text] The soft components of x-rays arising during solar eruptions cause changes in the properties of the ionosphere and affect the quality of long-distance shortwave communications. To forecast changes in the ionosphere it is important to know about the physical processes of solar activity. This purpose is served by investigation of changes in solar activity by means of instruments on board manmade satellites. This article gives a concise description of the development of these measurements and of the analyzer for the Prognoz 8 satellite.

Thermonuclear reactions and other processes taking place on the sun liberate large quantities of energy which propagate into the surrounding space in the form of various types of radiation. The latter reaches the vicinity of the earth, resulting in ionization of the outer layers of the atmosphere and thus producing the ionosphere. The ionosphere reflects radio waves, making possible radio communications over long distances, particularly in the shortwave bands. When eruptions occur on the sun, even more energy is given off. The radiation produces changes in the degree of ionization of the earth's atmosphere, resulting in temporary changes in the ionosphere which may lead to temporary loss of radio communications.

The shifting phenomena on the sun have other results as well: changes in weather, the occurrence of magnetic storms, a worsening of human health in the case of certain diseases, an effect on human psychology and the like. Obviously, forecasting solar activity is of great practical importance.

Solar physics attempts to explain the mechanisms of physical processes occurring on the sun during eruptions so as to gain a basis for forecasting them. Much important information is contained in the soft components of x-ray radiation, which are absorbed by the earth's atmosphere and cannot be recorded at the earth's

surface. Czechoslovak solar physicists became able to measure this radiation after the formation of Interkosmos, an organization of socialist countries for peaceful utilization of space. The Soviet Union gave this organization satellites and associated equipment for use free of charge. Instruments on board satellites moving outside the earth's atmosphere can record the soft components of x-ray radiation. This possibility was first utilized on 14 October 1969 on the Interkosmos 1 satellite, which carried the first Czechoslovak photometer for solar x-ray radiation. Further experiments were carried out on the Interkosmos 4, 7, 11 and 16 satellites. New instruments were prepared for each launch in accordance with the requirements of a team of physicists, and much scientifically valuable information was obtained.

These satellites had orbits 260 to 650 km above the earth's surface. During a single orbit, lasting about 90 minutes, the satellite passed through the earth's radiation belts as often as twice. The radioactive environment within these belts made recording impossible while the satellite was passing through them. Recording was also suspended when the satellite was in the earth's shadow, because the scientific apparatus had to be turned off to save power.

As time passed, the experiments began to require measurement of the sun's x-ray radiation in several energy bands, so as to record as much as possible of the time dependency of changes taking place during solar eruptions. None of the satellites mentioned above could meet the requirement for continuous measurement, and, accordingly, instruments for x-ray analysis were also installed on board the Prognoz satellites. These have a perigee of 500 to 2,000 km and an apogee of 200,000 km. The orbital time is more than 5,700 minutes (4 days) and the duration of the passage through the radiation belts is 4 to 6 hours during each orbit. With the orbital plane inclined at 65° to the equatorial plane, the satellite spends most of its time over the northern hemisphere (Fig. 1). As Fig. 2 shows, its orbit is extremely well suited for real-time reception of the telemetric signals from our geographic location. During about 90 percent of its orbital time, the satellite is in the zone of radio visibility, making possible almost continuous transmission of information. This satellite provides almost ideal conditions for monitoring solar activity.

The first x-ray analyzer was installed on the Prognoz 5 in 1976. The onboard equipment was designed using special hybrid circuits developed by TESLA Lanskrout and TESLA Hradec Kralove. The work continued on Prognoz 6 and 7, with constant modification of the instrumentation.

Measurements taken by the Prognoz 5 and 6 satellites have already been worked up into catalogs and are being used as the basis for scientific work. The results from measurements made by Prognoz 7 are now being processed by the Institute of Astronomy, CSAV, in Ondrejov. An example of the recording is shown in Fig. 3 and the computed values of the emission rate and plasma temperature are given in Fig. 4.

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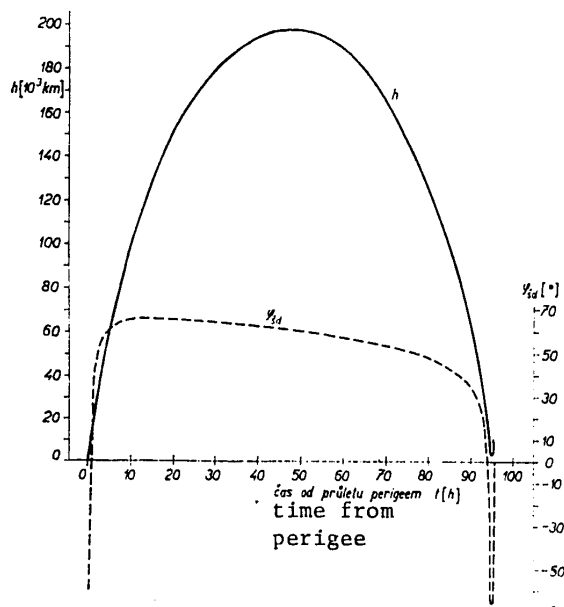


Fig. 1. Height of satellite above earth's surface and geographic width of subsatellite point  $\varphi_{sd}$  as a function of time since perigee.

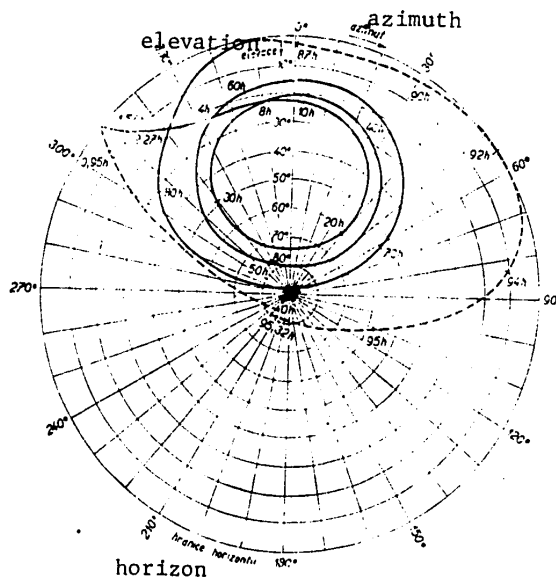


Fig. 2. Calculated path of Prognoz 5 satellite during 31st orbit, 24-28 March 1977, as seen from receiving center in Ondrejov. The observation site is at the center of the coordinate system. The dotted sections of the orbit are below the horizon. The time is figured from perigee.

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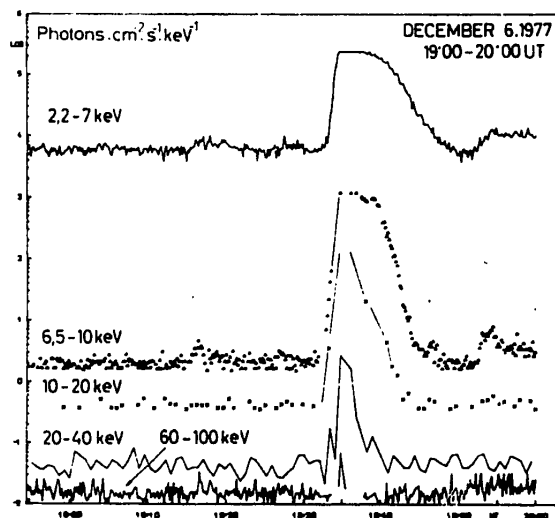


Fig. 3. An example of a computer-processed recording of a solar eruption. The measurements were made by Prognoz 6 on 6 December 1977 between 1900 and 2000 hours Universal Time. In the 6.6-10 keV region, to take one example, the number of quanta increased by 3 orders of magnitude.

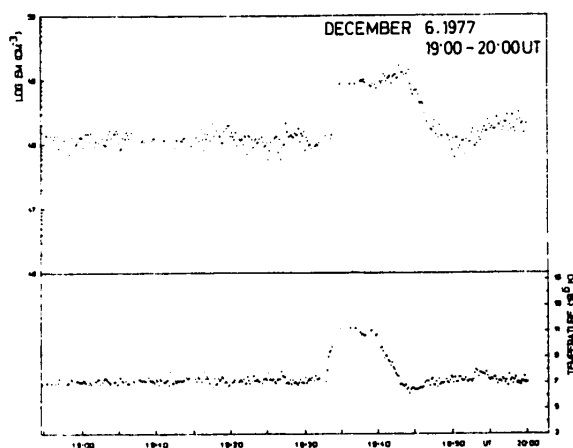


Fig. 4. Calculated emission rate and plasma temperature curves for the eruption in Fig. 3. During the eruption the emission rate increased by one order of magnitude, while the plasma temperature rose from 7 million to 11.5 million degrees Kelvin.

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The RF-2-P x-ray analyzers used on the Prognoz satellites were derived from those operating on the Interkosmos 11 and 16 satellites. Because the satellite telemetry system had only four channels for transmitting data on the radiation flux in six energy bands, the information had to be transmitted sequentially, and accordingly there was no guarantee that the information for the various energy bands was obtained simultaneously. In the new RF-3-P analyzer for the Prognoz 8 satellite, the readings are taken simultaneously on all six channels, making it possible to determine reliably the temperature of the plasma in which the radiation originates. Replacing analog intensitometers with digital-to-analog converters eliminated temperature dependency.

#### The Principle of X-Ray Radiation Measurements by the RF-2-P Instrument

Individual energy quanta reach the radiation detector through a window of precise dimensions. Electrical pulses are obtained at the detector output. Their amplitudes are proportional to the energies of the quanta which produced them. The number of pulses per unit time, or the pulse frequency, is proportional to the radiation flux. The electrical pulses are amplified and fed to an amplitude analyzer, which routes them to its outputs in accordance with their amplitudes. Each analyzer output corresponds to a particular pulse-amplitude range. Since the pulse amplitude is proportional to the quantum energy, the pulses at the various analyzer outputs correspond to specific energy intervals. The pulse frequencies at the individual outputs are proportional to the radiation flux in the ranges in question. The number of pulses per unit time is determined by a pulse counter, the intensitometer. The information on the pulse frequency is telemetrically relayed to earth. This method yields information on the spectral composition of solar radiation passing through the detector window. For completeness we should add that the shape of the spectrum is affected by the variation of detector efficiency as a function of energy, detector and amplifier noise, the accuracy of discrimination between ranges, and other factors such as the stability of the radiation detectors, the amplifiers, the high-voltage power supply and the like. Errors also result from the dead time, or recovery time, of the evaluation circuits and from possible superposition of two or more pulses following one another in close succession. There are a number of methods for eliminating these errors.

The RF-2-P analyzer uses two types of detectors, a scintillation detector and a gas-filled proportional counter.

The scintillation detector makes use of a sodium iodide plate 3 mm thick. When struck by an energy quantum or a charged particle, the plate scintillates. The flashes of light are recorded by a photomultiplier, and electrical pulses are obtained at the output.

To prevent passage of light through the scintillation plate, the entry window is covered with beryllium foil. The amplitude of the electrical pulse from the photomultiplier depends on the voltage across the latter. The high-voltage power supply (about 1,000 V) is, therefore, well stabilized. To assure constant energy conversion at the specified amplitude, good optical contact between the scintillation detector and the photomultiplier must also be assured.

The proportional counter is a tube closed at both ends and filled with gas, provided with a window covered with beryllium foil. A thin electrode passes through the tube, and there is an electric potential of about 1,200 V between the tube and the electrode. A quantum of energy passing through the window into the detector ionizes the gas. The applied voltage produces a change in the current passing through the detector and a voltage pulse occurs across the load resistance. The amplitude of the pulse is proportional to the energy of the quantum absorbed by the detector in the voltage range in question. The amplitude also depends on the power-supply voltage, the temperature of the gas in the detector, and the degree of aging of the gas. Accordingly, the working conditions of the proportional counter must be suitably stabilized.

#### Operation of the RF-3-P Analyzer

Voltage pulses from the scintillation detector SD + FN (Fig. 5) are amplified and shaped by pulse amplifier IZ. The shaping consists of integration and twofold differentiation ( $\tau = 1$  microsecond). This produces bipolar pulses with a zero DC component. The bipolar pulse has a positive section followed by a swing into the negative region. The purpose is to make the area bounded by the zero level and the positive part of the pulse equal to that bounded by the zero level and the negative part of the pulse. If the pulses were not bipolar in form, the DC component would change with frequency, resulting in errors in the comparison level in the amplitude analyzer.

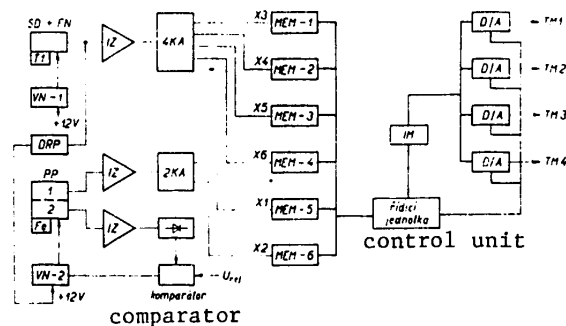


Fig. 5. Block diagram of RF-3-P x-ray radiation analyzer

Key:	SD-FM:	Scintillation detector probe	MEM:	Circuits for counting pulses during readings
	VN-1, VN-2:	High-voltage power supplies	IM:	Digital logarithmic intensitometer
	DRP:	Circuit for detection of radiation belts	D/A:	Converter with 8-bit memory logic
	PP:	Proportional counter		
	IZ:	Pulse amplifier		
	4KA, 2KA:	Amplitude analyzers		

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The photomultiplier of the scintillation detector is connected to stabilized high-voltage power supply VN-1. The photomultiplier's temperature is determined by semiconductor sensor T1 and the information is relayed telemetrically to earth, where it is used to correct the data in accordance with the measured temperature dependence of the scintillation detector.

The 4-channel amplitude analyzer 4KA contains five comparators and output logic. The comparators are set for specific levels corresponding to the boundaries between the various energy channels. The output logic assigns the pulses to the various outputs in accordance with their amplitudes.

Table 1. Distinction of Measuring Channels

<u>Detector</u>	<u>Channel</u>	<u>Energy range (keV)</u>	<u>Intensitometer capacity (pulses)</u>
Proportional counter	X1	2-4	16,192
	X2	4-8	8,032
Scintillation detector	X3	10-20	16,192
	X4	20-40	4,032
	X5	40-80	1,072
	X6	80-160	1,072

For correct analyzer operation it is important that the comparators be sufficiently stable and fast-acting. Because they are to be used on a satellite, there also arises a requirement for minimum power consumption. During preliminary experiments, several types of circuit were tested for amplitude discrimination. The CMOS logic gate proved to be the most suitable. The input voltage level at which the gate's output level changes is only very slightly temperature-dependent. There remains only the relatively great dependence on the power supply voltage. But if a stable power supply voltage is assured, the main problem of amplitude analyzer stability, i.e., temperature dependence, is eliminated. The use of CMOS logic solves the problem of power consumption at the same time.

The proportional counter PP is a dual unit. To assure that both sections have identical properties, they are mechanically identical, share the same gas filler and have the same working voltage. Section 2 has a radioactive preparation of  $\text{Fe}^{55}$  evaporated onto the input window. Its output pulses are amplified and after rectification the voltage, proportional to the pulse amplitude, is compared with the reference voltage by means of a comparator. The error signal is used to regulate high-voltage power supply VN-2. As the temperature changes or the gas ages, the working voltage of the detector PP, which is controlled by the feedback loop, changes in such a way that the pulses produced in the other part of the detector by the  $\text{Fe}^{55}$  preparation have a constant amplitude. Since Section 1 of the detector is identical with Section 2, a stable conversion of energy to pulse amplitude in it is assured.

The amplified and shaped pulses from the first part of the proportional counter are fed to the two-channel amplitude analyzer 2KA. This operates similarly to 4KA and is wired as shown in Fig. 6.

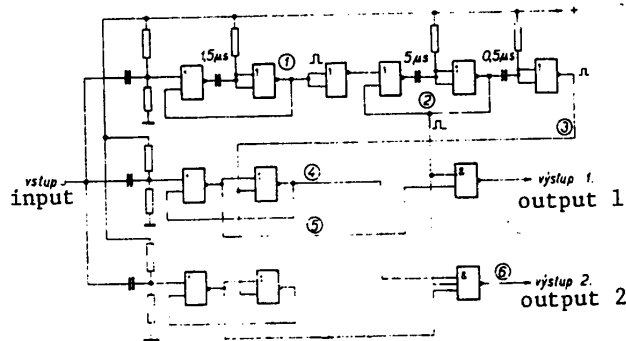


Fig. 6. Wiring of two-channel amplitude analyzer when CMOS gate is used as comparator

The high voltage from VN-2 is turned off while the satellite is passing through the radiation belts so as to prolong the life of the proportional counter. If the number of pulses from the scintillation detector exceeds a certain level, the radiation belt detection circuit DRP ceases to supply voltage to the high voltage converter.

The pulses from the amplitude analyzer are fed to intermediate memories MEM. These memory units consist of a K 176 IE model 15-bit binary counter and auxiliary circuits. The activity of the memory units is controlled by a control unit. Every 10 seconds a synchronizing pulse is fed from the telemetry system to the control unit. The MEM memory units receive instructions to take a reading every second. The pulses from the analyzer outputs are entered in the 15-bit counters every second.

After each reading, pulses with a frequency of about 120 kHz are fed from the control unit to the input of MEM-1 to fill up the 15-bit counter. The control unit determines how many pulses are needed to fill the counter. In this way it determines how many pulses the counter has recorded during the reading and relays this number of pulses to intensitometer IM. After counting of the pulses is completed in the intensitometer, the information from the intensitometer output is relayed by an 8-bit bus to the digital-analog converter D/A. The control unit causes the information to be entered into the 8-bit memory of the proper converter. The analog information is fed from the converter to the telemetry unit of 256 levels in a range from 0 to +6 V. After the information on the contents of MEM-1 has been entered into the memory of converter D/A, the control unit evaluates and records the contents of the other five MEM units in the same way. It takes about 1.5 seconds to evaluate and record the contents of all six MEM's.

The range of the intensitometer is variable and may have four magnitudes. The proper intensitometer range is set by the control unit for the MEM unit being evaluated. The intensitometer output voltage is logarithmically dependent on the number of pulses.

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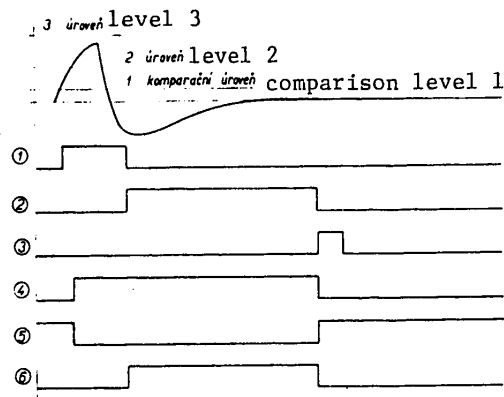


Fig. 7. Example of signal in the amplitude analyzer diagrammed in Fig. 6 when the amplitude of the bipolar pulse at the output is between the second and third comparison levels

The control unit has fixed CMOS logic. Among other things, it contains a crystal-controlled oscillator which gives the time of each reading.

A special tester was developed to break in, calibrate and check the operation of the individual parts of the RF-3-P x-ray analyzer. This device, including about 350 integrated circuits, allows both manual and automatic operation. Manual operation is used during laboratory checking of operation precision and allows analysis of possible malfunctions and their rapid location. Automatic operation is intended primarily for use of the tester by a person who is less familiar with the equipment during testing of an entire multidevice complex without the participation of experts on the individual pieces of equipment.

When the START button is pressed, the message GO lights up. Over the course of 20 minutes the individual parameters of the onboard device are checked one by one. The tester requires that the operator apply preparations to the input window of the detector, and only after he performs this operation does it proceed to further tests, at the end of which it lights up the READY indicator.

Light-emitting diodes go on during the individual tests to show which parameter is being checked. If the parameter being checked is within tolerances, the diode goes off. If none of the 56 LED's on the tester panel lights, the analyzer being checked is functioning properly.

During the course of 11 years' cooperation in Interkosmos, TESLA-VUST [A. S. Popov Research Institute of Communications Engineering] has developed a number of scientific onboard testing devices to the order of the Institute of Astronomy, CSAV. Some 21 of these, used for the study not only of solar activity but also of interplanetary matter and of the properties of the outer layers of the earth's atmosphere, have been installed on 12 spacecraft. They have included 56 individual devices.

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They have obtained many valuable scientific results and have provided much manufacturing experience and achieved considerable technical progress. This has affected the design of certain other devices for space research and equipment involved in the piloting of spacecraft.

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UNITED KINGDOM

NEW COMMUNICATIONS SATELLITE BEING BUILT

PM221115 London THE TIMES in English 22 Jul 81 p 3

[Report by Henry Stankope: "British Is Best for Satellite"]

[Text] The Ministry of Defence has acted as marriage broker in bringing together two British companies to build a new communications satellite for the armed forces.

The companies, British Aerospace and Marconi Space and Defense Systems (MSDS), have until now been rivals for a 100m contract, each teamed up with an American partner.

They were persuaded to come together to offer an all-British solution after the intervention of Mr John Nott, secretary of state for defence, and Lord Trenchard, minister of state for defence.

Mr Nott said yesterday: "We very much hope that cooperation between the firms will continue in future and that this will enable the United Kingdom to maintain a leading technological capability in space satellites."

The first of two satellites will be put into orbit in 1985, probably via the economical American shuttle. The other will act as a reserve. Defence sources say the first satellite will be the most advanced yet developed and will have a built-in defence against anti-satellite weapons.

The forces' last all-British satellite was Skynet-2, which was launched in 1974 and still in use during the run-up to the elections in Zimbabwe last year.

The use of Skynet declined after the ministry decided to use a common NATO facility. Last year the chiefs of staff concluded that they needed an exclusively British system after all, and the BAES/MSDS solution is the answer.

Although all the services will use the satellite, the Royal Navy is most in need of it. Vital forces, like the four submarines which carry Britain's Polaris missiles, will have a back-up system in case of emergency.

The British Aerospace Dynamics Division will make the satellite and will be the prime contractor, and Marconi will design the communications equipment inside.

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Space watchers say there is a 500m satellite market to be fought over in the next few years, involving similar systems for NATO and the Third World, and an additional chance of meeting the demands of civil customers.

Meanwhile the Ministry of Defence has still to decide on names for its two next satellites. "Charles" and "Diana" were loyally offered by reporters.

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